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HEALTH HAZARDS OF COSMIC RADIATION:

Following information is submitted in response to your recent request concerning safe exposure times to cosmic radiation at extreme altitudes. The information is condensed from a number of articles appearing in the August 1954 issue of the Journal of Aviation Medicine, and a book titled "Physical Environment of the Flier," by Dr. Heinz Haber, USAF School of Aviation Medicine, 1954.

The potential hazard to humans from exposure to the primary cosmic radiation at very high altitude centers upon the heavy nuclei component of the primary radiation. It is not the total ionization dosage of these rays which creates the potential danger but their extremely high specific ionization.

It has been shown that living cells which happen to be in or close to the central core of the ionization column of a heavy nucleus track are exposed in their full cell volume to ionization dosages as high as several thousand roentgens. Moreover, these dosages are administered in times far shorter than one millionth of a second and this circumstance is apt to increase the destructiveness of the heavy nucleus hit further. There is no doubt that such an exposure must be considered an above-threshold injury for the cells affected and that is putting it mildly. However, the percentage of cells of a human organism exposed to such extremely high dosages is very small even in a prolonged stay of many hours in the heavy nuclei region.

If one attempts to assess this novel type of radiation exposure with regard to its damage two questions arise. (1) Is this peculiar type of radiation injury, which severely damages a small percentage of the total number of cells but leaves the surrounding bulk of the tissue unaffected, bearable for all types of body cells? (2) If so , to what extent is it bearable? More specifically, how many hours exposure to heavy nuclei per day can be considered a below-threshold dosage? Present knowledge in radiobiology does not permit a rigorous answer to these questions. Since energy spectrum and mass spectrum of the heavy nuclei cover a wide range, this task of assessing the radiation hazard in quantitative terms is rather complex.

It seems too early to enter into a discussion of the radiobiological consequences of the data presented. With regard to the quantity of damage from heavy nuclei to living tissue, our knowledge at present is most fragmentary. Thus, the definition of a permissible exposure to be given in number of thin-down hits per day, is still a task for the future. The compliance with such an official permissible dosage,

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whatever its numerical value might be, will only be possible by restricting the daily or weekly exposure time in the heavy nuclei region. This permissible exposure time will vary greatly with altitude and latitude and will have to be calculated on the basis of the statistics of thin-down hits for the various components.

On the basis of the information and data available today, the following general conclusions may be assumed:

(1) Potential health hazards by repeated or long duration exposures at altitudes up to 70,000 feet, irrespective of latitude, are minimal. This is based on the assumption that the lower limit of atmospheric penetration of heavy primaries is approximately 65,000 to 70,000 feet. Physical or organic damage should not occur below these altitudes. However, as with all ionizing radiation, the long-time genetic effect of prolonged exposures to sub-threshold dosages is unpredictable.

(2) The effects of cosmic radiation between 70,000 and 120,000 feet will depend upon such factors as the precise altitude, latitude, duration of exposure, and the structural protection afforded the occupants of an aircraft. The heavy primaries are numerous in type, and have extremely high specific ionisation potentials, which imply marked tissue destruction. The effects of specific members of this group vary with altitude, some being maximal at 85,000 to 90,000 feet, others increasing in their destructive potentials up to 120,000 feet. Their potentials for destruction are due not only to their ability to ionize tissue in their immediate path, but to their final, more intensive destructiveness at their extreme point of terminal energy dissipation, or on what is termed "thin-down hits." The number of such hits varies with the geomagnetic latitude, and apparently reaches its maximum peak at 50° to 60° N. This effect is minimal at latitudes of less than 5° N.

The frequency of the destructive thin-down hits is also a function of the thickness of the shielding structural barrier. Insufficient shielding layers can act as intensifiers, and actually increase the number of thin-down hits. For adequate protection it is estimated that structural shielding material should consist of at least three inches of aluminum or one inch of steel. This is, of course, a prohibitively high weight penalty for aircraft design considerations.

(3) Protection of man from heavy nuclear hits seems possible only by limiting the total exposure time above 70,000 feet. Quantitative data for this cannot as yet be established, since no information is available as to the damage of a single hit and to the number of hits that can be considered a below-threshold exposure for the different body tissues. In general, however, it may be stated that short flight exposures above 70,000 feet will not result in any immediate or serious biological effects. It may be anticipated that repeated such exposures, resulting in cumulative pathological effects, will, after a period of time, result in serious tissue or body organ destruction. It would seem advisable then, to limit exposures above 70,000 feet to relatively short flights and at infrequent intervals until more information concerning the biological effectiveness of cosmic radiation is know.

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